E85-10028 NASA-CR-174119 SQT

Task Assignment 110 NAS5-28200
September 1984

LANDSAT INSTRUMENTS CHARACTERIZATION
GSFC ATR - Dr. J. Barker
SAR Task Leader - Dr. Y. Lee

Task Objective:

The objective of this task is to provide analytical and programming support for both Landsat-4 and -5 Thematic Mapper (TM) and Multispectral Scanner (MSS) instrument characterization, with emphasis on the radiometric performance.

Work Performed:

The following work was performed in the areas indicated.

140 Special Sub-Scene Selection

Twelve subscenes were selected from Landsat-5, scene 50129-17075 over White Sands, NM. Data set WHITE covers the entire White Sands desert area. Black-and-white films and hard copy prints of each band in this area were produced by LAS. Color films and prints are in processing. The 256 by 214 pixel eight-cycle pseudocolor pixel prints were generated on IDIMS for the mid-left subarea that covers some bright desert area, a small water body, and a part of an airport. Data sets WS1 through WS6 cover subareas of the White Sands desert. They were created for further detail scene feature studies. Data set WS7 covers a homogeneous water body. Data set WS8 through WS11 cover some homogeneous ground features. Particularly, data set WS9 includes a well-defined bright circular area and some stand-out road features. All subscenes created start at the first line of a forward scan. The forward and reverse scans misregistration had been corrected by shifting all forward scans 47 pixels toward the east.

A new command file was written for the Interactive Digital Image Manipulation System (IDIMS) to generate pseudocolor pixel prints of Landsat Thematic Mapper bands for data from B and A tapes. The file consists of 232 lines of IDIMS image processing, graphics, and arithmetic commands.

These commands apply pseudocolors to ranges of radiance numbers for each band and add appropriate annotation to the image. The current command file can handle multiple image sizes of 64, 128, or 256 lines and can make 1 to 8 cycles through an established pseudocolor look-up table for a range of 256 radiance values.

In making prints on the Optronics film recorder, a hardware timeout problem was encountered in the recording of the last 10 lines of each image data set. Systems personnel were notified of the problem. The SAR analyst was able to get the recorder to work by changing the size of the gray wedge in the image files.

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Task Assignment 110
September 1984

150 Spectrometry

The program PCMAIN.FOR of principal component analysis and a supplemental program HEDIT.FOR for generating sampled data sets have been developed. The procedures of performing principal component analysis on a subscene by using these programs are described as follows:

1. A 512 by 512 pixel subscene is sampled into 128 by 128 – 4 by 4 pixel grids. HEDIT.FOR samples the subscene data and calculates the mean μ_{ik} and standard deviation (SD) σ_{ik} for each grid. An option for generating radiometrically calibrated data has been included by applying normalized gains and offsets from either TRAPP report or TIPS QAR report line-by-line to the image.

2. In PCMAIN.FOR, pure pixel grid masks are generated by using coefficient variation (CV) thresholding criterion that pure pixel grid is defined as the grid whose CV, CV= σ/μ, is less than a given threshold value.

3. Mean μ_i and SD σ_i for each band are calculated based on the pure pixel grids of the subscene.

4. The covariance matrix C_{ij} for the subscene is calculated from the equation

$$C_{ij} = \frac{1}{n - N} \sum_k (\mu_{ik} - \mu_i)(\mu_{jk} - \mu_j)$$

where n is the total number of pure pixel grids, N is the number of bands, and $\sum_K$ is summing over all pure pixel grids.

5. Eigenvalues λ_i and eigenvectors t_{ij} are obtained by diagonalizing the covariance matrix C_{ij}

$$C_{ij}\, t_{ij} = \lambda_i\, t_{ij}$$

λ_i indicates the relative importance of each principal component.

6. The correlation matrix γ_{ij} among the spectral bands is calculated from the covariance matrix

$$\gamma_{ij} = \frac{C_{ij}}{(C_{ij})^{1/2}\ (C_{jj})^{1/2}}$$

7. The correlation matrix R_{ij} between the spectral bands and the transformed principal components is obtained as

$$R_{ij} = \frac{t_{ij}\ (\lambda_j)^{1/2}}{(C_{ii})^{1/2}}$$

8. An option for study of principal component analysis on the Z-transform data is included. An arbitrary normalized mean μ and SD σ are chosen as

$$\mu = \text{range}/2$$
$$\sigma = \text{range}/6$$
$$\text{range} = 255$$

to cover the whole range. Z-transform is defined as

$$\mu_{ik} = z_{ik}\ \sigma + \mu$$

and

$$z_{ik} = \frac{\mu_{ik} - \mu_i}{\sigma_i}$$

It normalizes all spectral bands to the same mean and SD. Steps 3 through 7 will then be performed to get statistics of principal component analysis.

Subscene WS1 through WS11 of Landsat-5 White Sands scene were studied. The first and the sixth components appear consistently in all scenes, and correspond to the first and sixth TM Tasseled Cap components, respectively.

200 TRAPP

Subroutine RCPARREA.FOR has been modified to distinguish Landsat-4 and Landsat-5 in orbit reference parameter files.

Subroutine RCRDDEFL.FOR has been modified to provide different sets of reference channels for TRAPP runs.

Subroutines RCDUMPHAT.FOR, RCDUMST.FOR, RCINJDISK.FOR, and RCLABREAD.FOR have been modified to change the TAE root to distinguish ADDS and CALDUMP runs.

310 Bright-Target Saturation

Bright-target saturation internal calibration (IC) lamp state dependence has been examined by using calibration data of night scene 50052-02182, WRS 111/212 over Harrisburg, PA. Eight scan lines corresponding to eight IC lamp states were plotted out. Only reverse scans were used because there are not enough background data after IC pulse in the forward scans. No bright-target saturation was observed in any plot, including plots of state 111, the brightest IC state. The 111 state in band 1 is higher than 200 and has been used as the threshold to search for the bright-target boundary of Landsat-4 TM. This indicates either Landsat-5 has a different response than Landsat-4 TM, or the IC pulse, which is only about 40 pixels wide, is not thick enough to trigger the bright-target saturation.

330 Scan-Correlated Shifts

Task personnel have routinely generated plots of line average background versus scan number for monitoring scan-correlated shifts. Plots have been generated for the following Barker specials.

Scene ID	WRS	Location
40171-17080	33/37	White Sands, NM
50129-17075	33/37	White Sands, NM
40608-15463	20/37	Birmingham, AL
50014-15460	20/37	Birminham, AL
50014-15465	29/39	Pennsacola, FL
50052-02182	111/212	Harrisburg, PA
40392-18152	44/34	San Francisco, CA

Scan-correlated shifts appear in all scenes and the characteristics are the same as reported in the Barker Result and Recommendataion paper. For the Landsat-5 scene, the background after dark current (DC) restoration stays the same as the background before DC restoration in most of the channels, but not for several channels in bands 1 and 5. For example, band 1 channels 2, 12, 14, and 16. This indicates that a strong DC restoration effect exists in these channels. The bright-target saturation effect was observed in the Landsat-4 White Sands scene, which is due to a large area of snow covering on the ground.

600 Investigator Support

Task personnel generated a data set of along scan high frequency matrix of Landsat-4, scene 40109-15140, over Washington, DC, for B. Markham. The ADDS tape was processed on Nov. 3, 1982.

800 Data Processing

Task personnel developed command procedures for batch job processing of image data transfer and BRU tape processing.

Task personnel processed three sets of in-orbit data and six BRU tapes.

900 Multispectral Scanner Subsystem (MSS) Coherent Noise Analysis

Histograms were made of the calibrated radiance numbers for the March 31, 1984, Landsat-4 and April 24, 1984, Landsat-5 detector responses for an area of water. Empty radiance number bins that were found in the calibrated data were different for the different detectors. As a result, empty radiance bins are complicating the analysis of coherent noise, particularly in the Landsat-5 data, which has a very low noise variance.

To reduce the impact of the empty bins, the NASA scientist suggested averaging the magnitudes of the Fourier transformed data for several 512 sample segments scattered throughout the water areas in each image. Six consecutive 6-line by 512-sample segments were chosen from each band, Fourier transformed, and the six magnitudes of the Fourier-transformed data were averaged and plotted. SAR identified the major coherent noise frequency peaks in the plots for both Landsat-4 and -5. The frequencies in the Landsat-4 data correspond closely to those reported in the literature. There were fewer noise peaks in the Landsat-5 data and the peaks were of much smaller magnitude than those found in the Landsat-4 data.

In addition, the NASA scientist requested that SAR do a coherent noise analysis of the unity radiance look-up table (RLUT) data when it becomes available. While waiting for the data, SAR investigated the possibility of inverting the radiometric calibration by using the calibration information contained within the ancillary and image files on the A-tapes. Four numbers are used in the calibration process; the filtered gain and offset values, which can be found in the image file records, and the multiplicative gain and additive offset values, which are found in the ancillary file. Only the filtered gain and offset values could be extracted from the tapes provided. The other two values were found to contain zeroes for each detector. It should be noted that due to roundoff and truncation errors, the calibration process is not absolutely reversible. Thus, it is preferable to use the unity RLUT data. The NASA scientist was notified of these problems.

The NASA scientist gave SAR a unity RLUT tape of Landsat-4 data for the March 16, 1984, MSS scene. Pixel subimages (512 by 512) were extracted from the Unity RLUT and the calibrated A-tapes. Examination on a display device revealed that the unity RLUT data was not of the same area. The NASA scientist was notified of the problem.

Significant Accomplishments:

On their own initiative and with ATR approval, task personnel developed software for the principal component analysis with and without Z-transform on both raw and calibrated data.

Problem Areas:

The LAS system was down eight working days during this month.

Forty-five BRU tapes received from Santa Barbara Research Center (SBRC) have a parity error on them. Task personnel have tried to modify subroutine PCBRUDATA.FOR to avoid this problem.

Schedule Conformance:

Work on this task has been completed.

Task Assignment 110
September 1984

Work Planned for Next Month:

A new task (132) will be assigned for the new fiscal year.

150 Spectrometry

Task personnel will study the principal component analysis on the classified data.

Deliverables Submitted:

Films and Graphics:	Landsat-5 scene 50129-17075 White Sands desert area
Originator:	Y. P. Lee
Plots:	Bright-target saturation IC lamp state dependence
Originator:	Y. P. Lee
Plots:	Line average background versus scan number
Originators:	J. Wang and Y. P. Lee
Listing:	Principal component analysis of White Sands subareas
Originator:	Y. P. Lee
Listings:	Pixel counts of radiance numbers for 24 detectors for Landsat-4 and -5 for an area of water
Originator:	W. Hallada
Listings:	Observed coherent noise peaks in Landsat-4 and -5 data for the first six detectors and for a sample of 512 pixels
Originator:	W. Hallada
Graphics:	Plots of the average magnitude of the Fourier transformed data for Landsat-4 and -5 for a sample of 512 pixels from six detectors
Originator:	W. Hallada
Graphics:	Polaroid prints of pseudocolored TM bands 1, 5, and 7
Originators:	W. Hallada and Y. P. Lee

Computer Utilization:

The estimated computer time used this month is as follows:

Minutes	Computer
3090 (wall clock)	HP-3000 (IDIMS)
200 (wall clock)	HP-3000 (ERRSAC)